INVOLUTION OF THE POST PARTUM UTERUS OF THE BOER GOAT

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ABSTRACT

The microscopic uterine involutionary changes were studied in Boer goats (n = 16) from 2 h to 34 d post partum. The endometrial epithelium showed a linear decrease in thickness with time post partum. A highly significant negative correlation (r = -0,94; P < 0,01) was found between the endometrial epithelium layer thickness and time post partum. The lamina propria layer showed a rapid decrease during the first 20 d post partum and then tended to level out. According to the statistical model ($y = Ae^{Bt+Ct^2}$) fitted by 25,2 d post partum, the thickness of the lamina propria layer was static.. The myometrium decreased significantly (P < 0,01) in thickness from Day 24 to Day 34 post partum. The thickness of the serosa followed a linear-type decrease during the observation period, while in the glandular epithelium the decrease was rapid during the first 12 d following parturition. The uterine glands reached normal size 22,1 d after parturition. The involution process of the uterus was microscopically complete by Day 28 post partum, the main indicator being the degree of recovery of the endometrial epithelium over the caruncular areas.

Key words: Boer goat, uterine involution, post partum, histology.

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INTRODUCTION

The productivity of any breeding female is determined by the number of progeny delivered in a given period of time. The interval from parturition to a subsequent pregnancy is a factor of major economic importance and hence the involution of the post partum uterus must be seen as one of the important limitations in achieving the goal of optimal reproductive efficiency.

Histologically, the uterine wall consists of 3 layers, namely the endometrium, myometrium and the perimetrium. The endometrium consists of a layer of simple columnar epithelium, with a lamina propria layer under the epithelial layer. The mucous membrane lining the uterine body and uterine horns have numerous prominent small round cupshaped caruncles embedded in the surface. The whole lamina propria is richly supplied with blood vessels, with the larger vessels being located towards the myometrium. Tubular glands are present throughout the lamina propria, except in the caruncular areas in ruminants. The myometrium consists of a thick inner circular and an outer longitudinal layer of smooth muscle cells, which increase in number and size during pregnancy. Deep in the inner layer, is a vascular zone consisting of large arteries, veins and lymph vessels. These vessels communicate with the endometrium. The serosa is composed of loose connective tissue covered by the peritoneal mesothelium. Smooth muscle cells and numerous lymph ducts, blood vessels and nerve fibres are present in this layer[1 5 13].

After distension and distortion of the uterine tissues during pregnancy and the heightened glandular development required to support the conceptus, the uterus must undergo contraction and loss of weight, together with extensive regeneration of its epithelial layers during the process of uterine involution[9]. The drastic drop in the mass and volume of the uterus of the ewe during the first 8 d following parturition, can be ascribed to the contraction of the myometrium, vasoconstriction and the loss of tissue fluids[1 6].

In contrast to sheep[2 12 13], relatively little has been reported on involution of the post partum uterus of the goat. According to Van Wyk[13] and Botha[2], uterine involution in sheep is complete 28 d to 34 d post partum. Most studies have however focused on the endocrinological status of the goat before and around partus[3 4 11].

This study therefore aims to describe histological changes in the uterus of the Boer goat after parturition.

MATERIALS AND METHODS

Multiparous Boer goats (n = 16) were slaughtered, one by one, at the following times after parturition: 2, 12, 24, 36 and 48 h, as well as 4, 8, 12, 16, 20, 24, 26, 28, 30, 32 and 34 d. The body mass of all animals was recorded prior to slaughter. The reproductive tract was removed and 2 tissue samples of the caruncles, with a section of the inter-caruncular area (at the bifurcation), were subsequently taken from each uterine horn and fixed in 10% buffered formalin solution. Following fixation and embedding, section of 6 to 10 μm were cut from all the specimens and they were stained according to the haematoxylin-eosin technique[8]. The sectional thicknesses of the different histological layers were microscopically measured with the aid of a calibrated eyepiece. Each layer was measured in 10 different positions on a line perpendicular to the layers being measured, and these measurements were converted and expressed in terms of μm. Each specimen was also histologically examined and the micro-anatomy described.

The microscopic involution process of the post partum uterus was described and predicted by the equation $y = Ae^{Bt+Ct^2}$, where y = parameter involved; A = value of parturition; B + C = constants; t = time interval post partum; e = base of the natural system of logarithms[10].

RESULTS

The body mass of goats is presented in Table 1 and the thickness of the different

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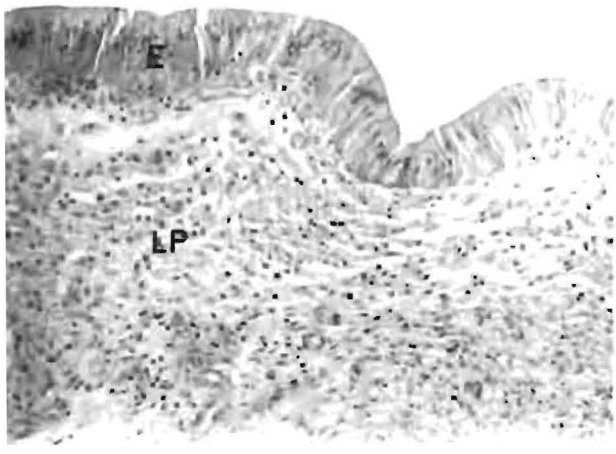

Fig. 1A: **The uterine endometrium 12 h post partum. The endometrium of the intercaruncular area is convoluted. Vacuoles are present in the cytoplasm of the epithelial cells. E - endometrial epithelium; L P - lamina propria (x 200)**

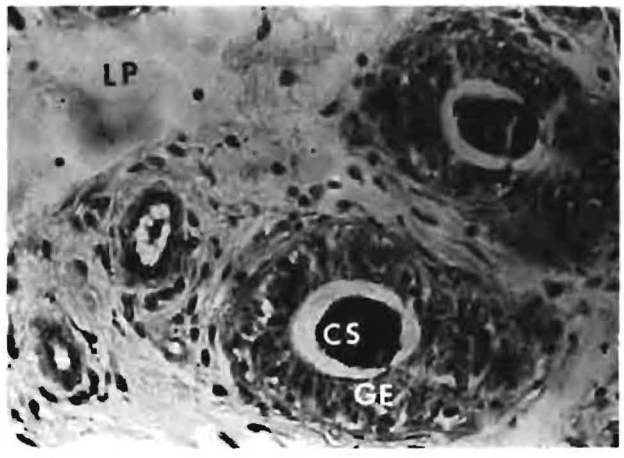

Fig. 1B: **The lamina propria 12 h post partum. The uterine glands are large and contain cell secretions, with vacuoles in the glandular epithelium. L P - lamina propria, G E - glandular epithelium; C S - cell secretion (x 320)**

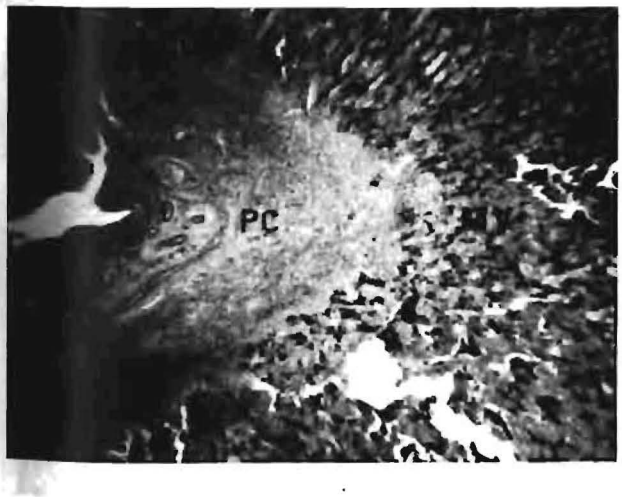

Fig. 1C: **The caruncular area 4 d post partum. The permanent caruncular tissue is contracted at the base of the maternal villi, which have degenerated. The proximal area of the maternal tissue is an amorphous mass of connective tissue. P C - permanent caruncular tissue, M V - maternal villi (x 12)**

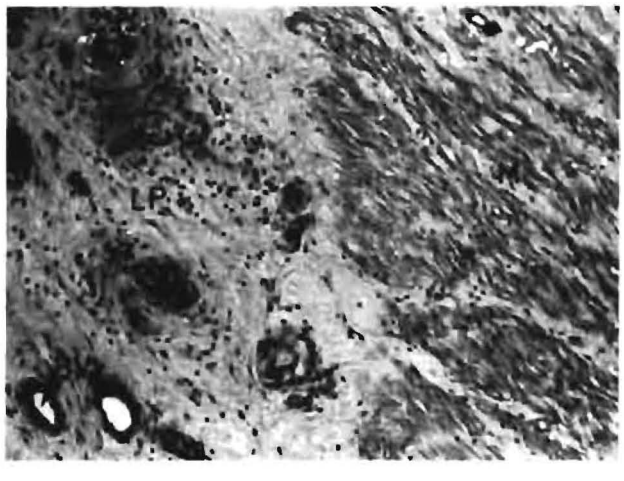

Fig. 1D: **The intercaruncular area 4 d post partum indicating the distinct border between the lamina propria and myometrium. L P -lamina propria; M - myometrium; B V -blood vessel (x 40)**

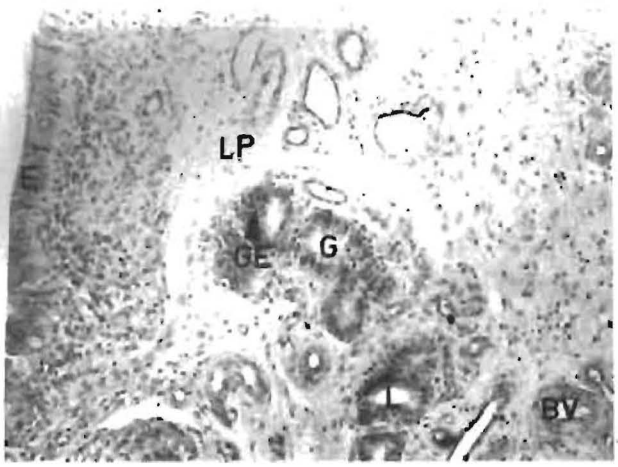

Fig. 2A: **The endometrium in the intercaruncular area 12 d post partum. The epithelium is convoluted and the lumen of the glands in the lamina propria contain cell secretions. E - endometrial epithelium; LP -lamina propria; G - uterine gland; BV -blood vessel; L - glandular lumen; GE -glandular epithelium (x 100)**

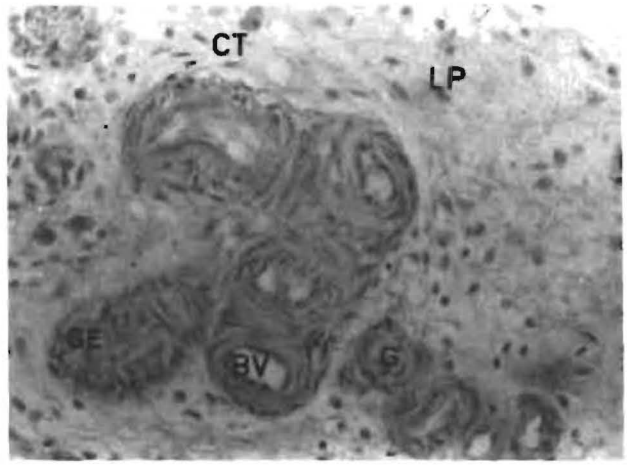

Fig. 2B: **The endometrial lamina propria 20 d post partum. The lamina propria consists of loose connective tissue with fibroblasts present and uterine glands with a few leucocytes present in the lumens of the glands. LP -lamina propria; G - uterine gland; GE - glandular epithelium; BV - blood vessel; CT - connective tissue (x 200)**

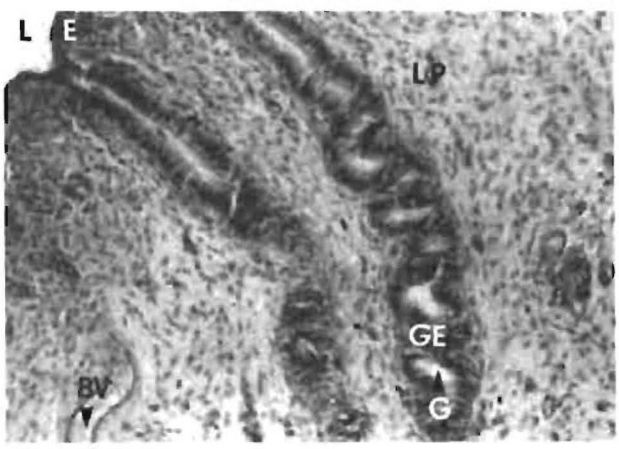

Fig. 2C: **The endometrium 24 d post partum. The coiled tubular glands are conspicuous. E -endometrial epithelium; LP - lamina propria; GE -glandular epithelium; BV -blood vessel; L - uterine lumen (x 100)**

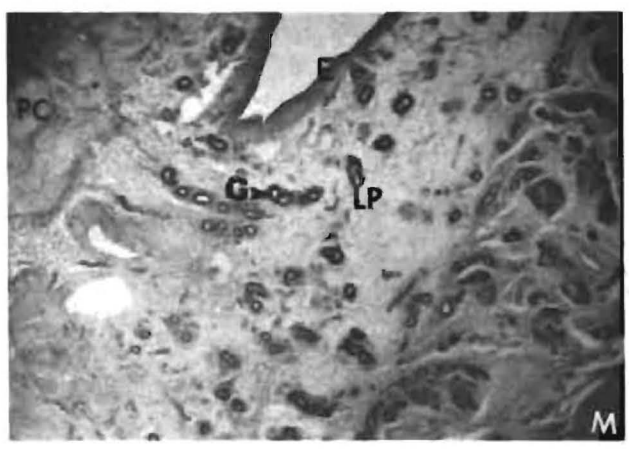

Fig. 2D: **The caruncle 34 d post partum. The endometrial epithelium is completely restored over the caruncle. E - endometrial epithelium; LP - lamina propria; G -uterine gland; PC - permanent caruncular tissue; M - myometrium (x 20)**

histological layers in Tables 1 & 2. The corresponding values attained by implementation of the equation $y = Ae^{Bt+Ct^2}$ for microscopic histological changes occurring in the post partum uterus, are presented in Table 3.

The endometrial epithelium (Table 1) of the uterine wall showed an almost linear decrease in thickness as time progressed, with a highly significant negative correlation existing between layer thickness and time post partum ($r = 0,94$; $P < 0,01$). Similarly, the thickness of the lamina propria showed a rapid decrease during the first 20 d post partum, and gradually decreased over the next 5 d to be complete after 25,2 d post partum (Table 1 and 3). The thickness of the glandular epithelium decreased rapidly during the first 12 d following parturition, whereafter the changes were much less marked (Table 2). A significant correlation ($r = 0,73$; $P < 0,01$) existed between the thickness of the glandular epithelium and the time post partum. The diameter of the uterine glands in the lamina propria showed a decrease of 6,3 ± 1,5% per day over the 34 d post partum observation period, with the normal original size being reached 22,1 d following parturition (Table 3). The myometrium on the other hand, decreased significantly ($P < 0,01$) in thickness from Day 24 (3 072,9 μm) to Day 34 (781,3 μm) post partum. The thickness of the serosa layer followed a linear-type decrease between parturition and 32 d post partum (Table 1).

The micro-morphological changes occurring in the caruncular and intercaruncular areas, from parturition to 34 d post partum, can be described as follows (The main indicator of the stage of the involutionary process was the degree of recovery of the endometrial epithelium over the caruncular areas): from parturition to 24 h post partum, the permanent caruncular tissue was horizontally spread out relative to the endometrium, with a hyalinised connective tissue layer showing constricted vascularisation, situated dorsally (lying ventral to the maternal villi). The columnar epithelium in the intercaruncular area was convoluted and the cytoplasm of the epithelial cells vacuolated. The lamina propria was richly vascularised and contained large uterine glands, filled with cell secretions and leucocytes (Fig. 1A, B). The thickness of the lamina propria was slightly less 12 h post partum than at parturition (Table 1). At parturition, the proximal area of the maternal villi were distinguishable as projections with cavities where the foetal villi were located, although no residual foetal villi could be identified as such. Cellular debris was present in some cavities. By 24 h post partum, the distal area of the maternal villi had degenerated into an amorphous mass, while in the proximal areas most of the hyalinised villi had retained their original structure. Epithelial cells of the maternal villi could still be distinguished, although many of their nuclei were pycnotic. By 36 h post partum, in the proximal area of the permanent caruncle tissue, the blood vessels were constricted as a result of hyalinisation in the artery walls. By 4 d post partum, the permanent caruncular tissue (Fig. 1 C) had contracted, with a hyalinised connective tissue layer situated dorsally being prominent. The epithelial layer of the endometrium in the intercaruncular area was convoluted, with vacuoles in the epithelium cells occurring in this post partum period. Where the epithelial cells of the proximal area of the maternal villi were still readily discernible 36 h post partum, the epithelium cells had almost completely degenerated by 4 d post partum, having an amorphous appearance. The thickness of the different histological layers (Fig. 1D) showed a steady decline from parturition to 4 d post partum. The lumens of the uterine glands in the lamina propria had also decreased in diameter during this stage (Table 2) and contained cell secretions and leucocytes. By 16 d post partum, there were indications that the epithelial endometrium of the intercaruncular area was starting to progess from both sides over the permanent caruncular area, just underneath the hyalinised band of connective tissue which was loosely attached to the permanent caruncular tissue (Fig. 2A). Fragments of necrotic tissue had broken loose from the permanent caruncular tissue and there was a definite border between the necrotic tissue and caruncular tissue. At this stage, the columnar epithelium of the endometrium had decreased in thickness and was less convoluted than at any previous stage. During the period 20 d -26 d post partum, the permanent caruncular tissue had contracted to its normal mass of fibroblast cells and fibres. The hyalinised band of connective tissue, together with the rest of the necrotic tissue derived from degeneration of the maternal villi, had come loose and were expelled through the cervix by Day 20 post partum. By Day 20 post partum, the diameter of the uterine glands and thickness of the glandular epithelium (46,3 μm and 18,7 μ respectively) were approximately those of the non-pregnant uterus (53,4 μm and 16,9 μm respectively)[7]. At 26 d post partum, some uterine glands still contained secretions in their lumens. Individual variation existed in the thickness of the endometrial epithelium, lamina propria, myometrium and serosa layers between the 20 d - 26 d post partum period (Table 1), but in all cases it was substantially less than at parturition. By 26 d post partum, the endometrial epithelium covered the entire caruncle surface, although the columnar epithelium did not appear to have the same thickness over the entire caruncular surface (Fig. 2B, C).

During the latter stages of the observation period (28 d - 34 d post partum), the cross-sectional thickness of the columnar epithelium and lamina propria of the endometrium was similar to that of the normal non-pregnant goat uterus (19,2 μm and 1192,7 μm respectively) (Table 1). Leucocytes present in the uterine glands of the lamina propria during this period were sparsely distributed. The number of glands per unit surface area (Table 2) in the lamina propria had increased (due to a decreased diameter in lumen of the glands) to a mean count of 60,6 per unit surface area. The endometrial epithelium was fully restored over the entire caruncular areas by Day 28 and by 34 d post partum, the myometrium and serosa layers were also completely normal (Fig. 2D).

DISCUSSION

By Day 28 post partum, the epithelium and the lamina propria of the endometrium in the intercaruncular area were of normal thickness and compared well to the normal non-pregnant goat uterus. Similarly, the uterine glands and glandular epithelium at this stage were similar to those of the non-pregnant goat[7] - suggesting that the endometrium was completely involuted at this stage. This ties in with the statistical model fitted, according to which the post partum changes in the thickness of the lamina propria layer are static 25,2 d post partum. The initial rapid decrease in thickness of the lamina propria can be attributed to a loss in tissue fluid, due to the connective tissue cells of the lamina propria becoming more tightly grouped, vasoconstriction and the involution of the uterine glands[2]. The glandular epithelium (Table 2) showed a relatively rapid recovery in terms of cell layer thickness - which is in agreement with the findings of Van Wyk[13]. The myometrium decreased significantly in thickness from Day 24 to Day 34 post partum, thus, relatively late post partum. By Day 28 post partum, the myometrium and serosa were slightly thicker than in the non-pregnant animal. The serosa followed a linear decrease between parturition and Day 32 post partum, before starting to level off at Day 34. The serosa, composed of loose connective tissue (although smooth muscle cells, lymph, blood vessel and nerve fibres are also present in this layer) could be partly responsible for its relatively slow recovery rate, due to the connective tissue taking longer to become more compact.

In the caruncular area, the permanent

Table 1: **The mean microscopic cross sectional thickness (μm) of the different histological layers in the uterus of the post partum Boer goat**

Goat No.	Goat mass (kg)	Birth status	Days post partum	Endometrial epithelium (μm)		Lamina propria (μm)		Myometrium (μm)		Serosa (μm)	
				LH	RH	LH	RH	LH	RH	LH	RH
R24	67,2	2	0,1	46,7	40,4	3 399,7	3 544,9	2 430,6	2 987,5	231,0	179,0
R23	62,5	1	0,5	46,7*	42,2	2 938,3*	2 923,4	2 203,1	2 118,8	274,5	232,1
R30	54,8	2	1	39,0	38,7	3 601,1	3 446,6	1 725,0	1 850,0	186,7	220,8
R3	58,7	1	1,5	36,8	37,8*	2 232,3	2 242,1*	2 187,5	1 571,4*	256,0	200,0*
R27	57,0	2	2	35,2	35,5	1 671,8	1 557,1	2 343,8	1 843,8	262,4	224,0
R13	65,8	2	4	34,9	32,0	1 389,9	1 376,8	2 968,8	2 357,3	180,6	146,7
R5	54,3	2	8	31,7	30,4	870,5	947,0	2 593,8	2 734,4	144,5	113,5
R9	55,5	2	12	34,9	35,2	1 262,0	1 491,5	1 562,6	2 431,4	105,1	126,0
R10	58,6	3	16	27,5	29,1	832,6	953,9	3 304,7	2 968,8	113,4	94,6
R28	50,4	2	20	22,7	25,9	1 396,4	1 022,7	2 156,3	2 687,5	94,2	78,6
R15	55,8	2	24	24,6	23,0	943,2	1 098,1	2 968,8	3 176,9	99,2	104,7
R17	51,4	2	26	24,6	25,9	845,7	953,9	1 109,4	1 238,4	48,8	47,2
R8	54,1	2	28	23,0	24,6	960,5	1 045,6	1 875,0	1 722,0	83,2	75,2
R21	52,2	2	30	19,8	18,2	963,7	1 212,9	1 546,9	1 316,9	66,2	76,2
R25	59,1	3	32	16,3	16,8	826,1	668,7	1 120,5	1 226,0	58,2	49,0
R6	65,0	1	34	16,6	15,7*	757,2	891,6*	781,3	781,3*	49,9	53,8*

LH = Left uterine horn
RH = Right uterine horn
* = Non-pregnant uterine horn

Table 2: **The mean cross sectional thickness, diameter and number per surface area of the uterine glands of Boer goats from parturition to 34 d post partum**

Goat No.	Days post partum	Thickness of glandular epithelium (μm)		Diameter of glands (μm)		Glands per surface area	
		LH	RH	LH	RH	LH	RH
R24	0,1	29,9	26,0	169,6	151,7	26,3	19,7
R23	0,5	26,6*	32,0	107,5*	118,1	59,3	26,0*
R30	1	33,0	31,7	79,4	80,6	10,0	10,7
R3	1,5	28,6	27,8*	84,5	84,5*	7,3	12,5
R27	2	18,2	20,2	61,7	57,9	33,0	25,0
R13	4	19,8	17,6	62,1	56,0	16,3	18,0
R5	8	21,4	25,9	60,8	57,0	19,3	16,0
R9	12	17,3	22,1	57,3	53,4	15,6	18,7
R10	16	19,2	18,2	51,8	50,9	17,0	23,5
R28	20	20,8	16,6	50,0	42,5	17,3	23,0
R15	24	19,5	16,6	52,9	48,4	56,3	44,0
R17	26	17,9	19,2	59,5	52,2	30,7	74,7
R8	28	17,6	19,5	53,1	54,7	67,8	53,3
R21	30	19,8	21,1	53,1	70,1	33,3	34,3
R25	32	17,3	18,6	51,8	44,8	73,7	47,7
R6	34	16,6	16,6*	41,6	46,1*	92,0	89,0

LH = Left uterine horn
RH = Right uterine horn
* = Non-pregnant uterine horn

caruncular tissue was very prominent throughout the study. The rate of involution could be monitored by the degree of shrinkage of this tissue. At parturition, the proximal area of the maternal villi, which consisted of connective tissue, in which blood vessels were readily visible, was easily distinguishable. The vertical cavities where foetal villi were located could be identified, although no residual foetal villi could be recognised as such.

The cavities between the maternal villi (where the foetal villi were located), rapidly shrunk and were not so readily discernible because the distal area of the maternal villi degenerated into a relatively amorphous mass by 24 h following parturition. At this stage, the cells were in various stages of pycnosis and this process progressed with time. By Day 2 post partum in the caruncular area, the

Table 3: **Values attained by using the equation $y = Ae^{Bt + Ct^2}$ for microscopic histological changes occurring in the post partum uterus of the Boer goat**

Variables y	A*	B**(x 100) ±SE	C ± SE	Day of no change[00]	Value[000] of y at day of no change
Endometrial epithelium (μm)	38,80	-1,3 ± 0,62	-0,00032 ± 0,0002	-20,2	44,18
Lamina propria (μm)	2610,56	-8,7 ± 1,78	0,00172 ± 0,0006	25,2	875,46
Myometrium (μm)	2059,45	5,0 ± 1,58	-0,00212 ± 0,0005	11,8	2759,08
Serosa (μm)	222,65	-5,9 ± 1,30	0,000547 ± 0,0004	53,8	45,85
Glandular epithelium (μm)	26,89	-3,3 ± 0,98	0,000687 ± 0,0003	24,2	18,00
Glands (μm)	95,36	-6,3 ± 1,46	0,00143 ± 0,0005	22,1	47,31
Glands/ surface area	17,55	1,8 ± 2,54	0,00191 ± 0,0008	4,6	16,86

*value at parturition
**percentage in- or decrease in y/day; $c \neq o$
$^{00}t = \frac{-B}{2c}$; $c \neq o$
$^{000}c \neq o$

hyalinised band of connective tissue which formed ventrally to the maternal villi, appeared thicker, more prominent, with a translucent appearance - this is in agreement with findings by Van Wyk[13] in sheep, and he also found that this hyalinised band of connective tissue became thicker and more prominent as time, post partum, progressed. Botha[2] found the arterial and venous blood vessels in this band of connective tissue to be completely constricted by Day 12 post partum. By Day 4, the connective tissue of the maternal villi had degenerated to such an extent that the bases of the villi were no longer identifiable. The epithelium cells of the maternal villi were also not identifiable and the area nearest to the permanent caruncular tissue could only be seen as an amorphous mass at this stage - consisting of connective tissue in which fibroblast cells were present. This necrotic degeneration of the maternal villi progressed, so that by Day 16 post partum, fragments broke loose from the permanent caruncular tissue, which had become even more compact. As the involution process progressed, so the separation between the proliferating connective tissue (ventral to the hyalinised band) and the hyalinised band progressed, until the necrotic maternal tissue and the hyalinised band completely broke loose from the underlying connective tissue and permanent caruncular tissue.

The endometrial epithelium had already started to proliferate from both sides of the intercaruncular area, over the permanent caruncular tissue by Day 12 post partum in the Boer goat, and was 75% complete by Day 24 and completely covered the caruncles by Day 28 post partum. At this stage the permanent caruncular tissue was contracted, with fibroblast cells and fibres compactly arranged - microscopically the uterine involution process in the Boer goat was complete. This stage is reached by Day 30 post partum during the breeding season, and Day 32 to Day 34 post partum outside the normal breeding season in sheep[2] while Van Wyk[13] quotes involution as being microscopically and macroscopically complete by Day 28 post partum, which is in agreement with the time of uterine involution in the Boer goat.

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